UDC (UDK) 631.354:631.1

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EFFECTS OF THE THRESHING HARVESTER DEVICE AND ITS INFLUENCE ON THE BREAKAGE AND DAMAGE OF BUCKWHEAT AND RYE DEPENDING OF PREDEFINED PARAMETERS

SUMMARY

The harvest of buckwheat and rye can be performed over multiple phases, two phases, or just one single phase. The quality of the thresher device's work depends on several factors: the state of the crops, the definitions of relevant parameters, technical accuracy, and staff skills. When the relevant parameters are not well coordinated, quality can significantly decrease, and it can result in losses and impurities, as well as broken and damaged grain in the threshed mass of the combine bunker. As with seed supplies, in processing grain, the contents of the broken, damaged kernels and impurities is undesirable. In seed goods and goods for processing, broken and damaged grains complicate cleaning and storage, and reduce the quality of the resulting product. A threshing device on a harvester has a significant impact on the quality of threshed buckwheat and rye. The quality of work is affected by numerous factors: moisture of the crops and compliance with the thresher drum's parameters. The aim of our study was to compare trials with two types of combines with a TTO threshing device and to determine the effects and impact of altered parameters on the quality of threshed buckwheat and rye, which will make obvious the shortcomings and advantages of the threshing apparatus. The research used the threshing devices of the combine ZMAJ142 and ZMAJ 135B. The humidity was 16.2% for the rye and 19.8% for the buckwheat. Based on the results it can be concluded that the highest content of intact whole grain buckwheat varieties (96.25%) was measured in the thresher that had corrected the defined parameters for the threshed combine mass of 135B. The lowest (92.86%) was measured in the Z142 combine harvester (the control). The highest average content of whole grain rye (97.24%) was recorded in the first threshed combine mass (a variant of the correction parameters), and the lowest (94.75%) was measured in the threshed combine mass of Z142 (control). Threshing devices that corrected the relevant working parameters peeled and broke buckwheat and rye grain during harvest significantly less than the control did. The minimum content of broken grains and dehulled buckwheat stood at 1.15%, with a peripheral drum speed of 16.69 m s^{-1} and a clearance of 20 mm between the concave and drum at the entrance (harvester Z135B). In the threshed mass of the other tested combine, a very high content (3.14%) of broken grains

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and dehulled buckwheat was measured (concave gap-16 mm drum, a drum peripheral speed of 25.12 m s^{-1}). A similar effect occurs in the parameters defined for breakage and damage during the harvesting of rye, so that the minimum content of broken grains are recorded in the threshed mass of the corrected variant, amounting to 0.86% of 1600 (with a peripheral drum speed of 25.91 m s^{-1}, gap-concave drum 20 mm), while the highest was recorded in the control of the other variant combine, testing at 1300 and amounting to 2.36%, with a peripheral drum speed of 32.97 m s^{-1} and a gap-concave drum of 16 mm.

Key words: buckwheat, rye, threshing device, quality, grain.

INTRODUCTION

Buckwheat is a special field crop and its importance derives from its use. Grown for grain that is rich in compounds of iron, potassium, phosphorus, and citric, malic, and oxalic acid, it is also rich in the vitamins B1, B2, PP, and belongs to a group of good nutritional products (Joshi et al., 1991). In the past, buckwheat had been neglected in plant production, but in recent years its role has expanded to larger areas. The case with rye is similar, though it is an essential raw material for baking bread and it contains the vitamins A, B, and E (Oelke, et al. 1990). Rye is a tasty and nutritious bread, and it stays fresh longer than other breads. Moreover, rye bread is especially recommended for diabetics. Rye is excellent cattle food, either when green, or in the form of bran, flour, or grain. The grain can be used to produce alcohol, vinegar, starch, cellulose, lignin, furfural, and paper of good quality, and the seeds are used in the pharmaceutical industry. Dragović (2012) reports that the main agricultural region of Serbia has favourable soil and climatic conditions for successful rye crops.

The quality of a wheat combine depends on several factors: the state of the crops, the definitions of relevant parameters, technical accuracy, and staff experience. When the relevant parameters are not well-coordinated, quality can significantly decrease, resulting in high impurity content, with broken and damaged kernels in the bunker of the harvester. As with seed supplies, and in grain processing, broken, damaged kernels and impurities are undesirable. In seed goods and goods for processing, broken and damaged grains complicate cleaning and storage, and reduce the quality of the resulting product.

The threshing device on a harvester has a significant impact on the quality of the threshed grain. The quality of output is further affected by numerous factors: moisture in the crops, the compliance of the drum-concave with the rotation speed of the drum, the type of threshing device. Well-defined parameters are a prerequisite for quality work on threshing equipment and a good quality of threshed mass. Analysing the work and the results of other authors' work, we can definitively state the significant effects of these issues. Auld et al. (1986) reported that the well-tuned threshing devices of a combine's low losses can be achieved by the threshing device (about 1%) and more than 93% of the whole grain harvesters in the bunker.

While examining the effects of the harvester "Đuro Đaković M-1620 H", the purity of grain was satisfactory because the whole grains in the sample from the bunker were represented, ranging from 96.30% to 97.51% (Čuljat et al., 1987). For a lower speed of combine when harvesting buckwheat, slow the peripheral speed of the drum and allow for the presence of a gap between the concave and the drum at the entrance to reduce losses to less than 1.5%. The sieve at the top should be open to 16-18 mm and the bottom sieve should be no more than 5-10 mm, so the threshed weight is made of more than 90% whole grain, (Oplinger et al., 1989). A smaller number of revolutions of the drum and a larger gap between the concave entrance and the drum provide an opportunity to gain quality threshed-mass with a high content of whole grain, states Mayers et al., (1994).

The quality of threshed weight is satisfactory if it contains more than 90% whole grains and less than 1% unthreashed shed grain, (Čuljat, 1997). Small losses of buckwheat seeds on the threshing device and over 90% whole grain allow the low speed of the combine (oko 5 km h^{-1}) and the proper selection of the peripheral speed of the drum and the gap at the entrance to the threshing device (Beuerlien, 2001). Modern grain combines must have an effective threshing device that allows over 90% pure grain in the threshed mass (Vojvodic, 2002). Since Mansoori and Minaee (2003) concluded that an increase in the cylinder’s rotational speed from 750 to 950 rpm would double grain breakage, we chose to implement a rotational speed of 800 rpm. Losses from the combine threshing machine should not be over 0.8% and impurities in the threshed mass not over 2%. Considering the effects of harvesting wheat in the agro-ecological conditions of Srem, Djokic (2003), states that with the combine JD 2264, of the threshed mass, 97.10% of it was whole grain weight, 0.75% was broken, 1.10% was poor and 1.05% contained other impurities.

By studying the modern grain harvester Claas Lexion 450 in exploitation conditions, harvesting wheat and maize, Djevic et al. (2004) state that, depending on the defined parameters and speed of movement, the whole grain in the threshed mass went from 86.17% to 93.41%, with 0.29% to 0.36% impurities. The structure of the mass in the combine bunker bumped whole wheat grains from 94.79% to 95.37%, with 0.48% to 0.65% damaged, 0.56% to 2.47% broken, and mechanical impurities from 0.09% to 0.16% (Malinovic et al., 2005). Barac et al. (2006) reported that the highest percentage of whole grain in the Z142 combine harvester was 95.93% in a distance concave-drum 20 mm, with a peripheral speed of 26.70 m s^{-1}. However, at a minimum distance, a concave-drum of 12 mm with a drum peripheral speed of 33.00 m s^{-1}-94, produces 77% whole grains. The content of broken grains varied in the range of 2:01 to 2:25%. The same authors state that the threshed mass structure of the JD 2264 combine was 97.34-98.48% healthy whole grains, and 0.75-1.15% broken grains, with a drum peripheral speed of 27.60 and 31.10 m s^{-1} and a gap between the concave and drum at 10 and 15 mm. During buckwheat harvesting, using the JD 6620 combine, the gap between the concave and drum was about 20 mm, with a fan speed of 600min,[1] sieves open at 10-15 mm and 5-10 mm above the bottom, and over 90% of the whole grain was threshed (Mayers, 2007). For better harvesting, buckwheat desiccation is recommended, carried out with 1% ethanolic magnesium chloride, and 7 days after the harvesting is done (Stanisic, 2008).The interaction of speed of movement, rotation speed, and the distance the concave-drum exhibited with such a significant influence on grain cracking. The highest yield and fracture was 5.47%, with losses in free grains of about 1.5%. The authors therefore suggest a low speed of about 2 km h^{-1}, a rotation of the drum at 800 min^{-1} - 900 rpm^{-1} with the inlet height of 25 mm (Lashgari et al, 2008.).

MATERIAL AND METHODS

In the exploitation conditions of Kosovo and Metohia, on two experimental parcels of land in 2011, comparative tests on the work effect of classic threshing devices were made (TTO), just like the tests on the quality of threshed mass of two types of combines during the harvest of winter rye and buckwheat. Harvesters examined ZMAJ 135B, which has been in exploitation for years, and ZMAJ 142 which has been in operation for several decades.

Research into the effect of work on the threshing device was carried out in the agro-ecological conditions of the northern part of Kosovo and Metohia. Two locations were chosen, the area of Leposavic (430 27’14’’N; 20013’49’’E) and Lesak (43012’46’’N; 20042’93’’E), with the humidity of the grains of the rye and buckwheat during the harvest being 16.2% and 19.8%. In the first experimental plot, a native variety of buckwheat was planted on one side and rye on the other (sort Rasa). After the choice of parcel, the biological yield of winter rye and buckwheat by diagonal parcels was determined. We found that the crops grew upright without the significant presence of weeds, equalized, and did not prostrate. The average yield of buckwheat was 975 kg ha-1 and rye 2321 kg ha-1. Tests were carried out, and the first rye harvest was performed with both the experimental plot combine, while the harvest of buckwheat was later performed on the selected parcel of land. The quality of the threshed mass is expressed by the weight and content of the healthy (whole), smashed, peeled, poor and partially damaged kernels, and through the mechanical impurities. Quality was determined by sampling the weight of 20kg of threshed mass from the combine’s bunker with three replications, where the number of samples and combine work modes were followed. The percentage by weight and content of individual fractions was determined later in the laboratory. The experiment was carried out on the track length of 50 m in three replications. The combines were examined using the setting published by the owners as a control and were evaluated according to results obtained based on our set of parameters. The working speed of the combine was determined by measuring the amount of threshed mass in use, and the rotation of the drum on the three shin devices was read from an RPM meter. The applied methodology was standard for the field-laboratory and exploitation tests and refers to the testing of equipment for harvesting (ISO

8210). The results are analysed and presented in tabular form. Table 1 shows the number of technical characteristics of the tested combines.

Table 1. Technical data of examined combine harvesters

Parameters		Tipe of combine harvesters	
		ZMAJ 135B	ZMAJ 142
Engine power	(kW)	51.5	73.1
Heder engagement width	(m)	3.05	4.20
Drum width	(mm)	790	1000
Drum diameter	(mm)	550	600
Power per header grip	(kW m^{-1})	17.1	17.40
Combine mass	(t)	5.32	7.18
Hopper volume	(m^3)	1,8	3.60
Hopper volume/engagement width	(l m^{-1})	0.60	0.86
Surface of straw shakers	(m^{-2})	2.6	3.9
Surface of cleaning (m^2)	(m^{-2})	1.6	2.53
Comprehensive concave angle of the underdrum	^{0}	145	112

RESULTS AND DISCUSSION

In Table 2, data are shown regarding the buckwheat and rye at the harvested experimental fields, as well as regarding the regime of the examined combines. Based on the revealed data, it can be seen that the examined combines have been operating under good conditions, achieving yields of 975 kg ha^{-1} of buckwheat and 2.321 kg $ha^{-1}$of rye.

Table 2. Basic data about crop and combine harvester working regime

Parameters		ZMAJ 135B	ZMAJ 142
1		2	3
Crop			
Cultivar		Buckwheat	Rye
Grain yields	($kgha^{-1}$)	975	2.321
Grain moistture	(%)	19.8	16.2
The average height of the plants	(m)	1.18	1.45
Plant texture bym^2		/	460
Crop condition		Vertical without weed	
Combine harvester			
Fan revolution	(min^{-1})	670	700
Sieve seting:extension, upper,lower	(mm)	15; 11; 5	16;12; 5
Working speed	(m s^{-1})	0.69 and 0.93 0.76and0.98	0.86 and 1.00 0.90 and 1.15
Space underdrum-drum at the entrance	(mm)	16 and 20	16 and 20
Mass flow of the grain	(kgs^{-1})	1.50 and 3.20 3.35 and 3.68	2.4 and 4.18 4.19 and 4.57
Drum peripher rotation	(m s^{-1})	16.69 and 23.03 25.91 and 30.22	17.27 and 25.12 28.26 and 32.97
Directors		G. S. S	G. S. S

A lot of grain mass was also in evidence. The crop has been vertical at both experimental fields, and it has not been afflicted by the significant presence of weeds.

In the Table 3 there are exposed data regarding the quality of work, the examined combines, and the quality of the harvested buckwheat and rye grains in the combine's bunker, all depending on changes in the defined parameters as compared to the control.

Based on the results exposed in the Table 3, it can be concluded that changes in the defined parameters and the work regime of the examined combines' harvesting devices compared to the control have significantly influenced the quality of harvested grains of buckwheat and rye.

Table 3.Quality of threshed grain from hopper of examined combine harvesters

Combine type	Working speed ($m\ s^{-1}$) and time samling	Underdrum-drum (*mm*)	Drum speed ($m\ s^{-1}$)	Structure of a harvested grains (average)									
				Whole grain		Poorly grains		Broken and pealed		Partialy damaged grains		Mechanical impurities	
				%	kg	%	kg	%	kg	%	kg	%	kg
Quality of the harvested buckwheat grains from bunkers of the examined combines													
Z135 B	0.69 (1 p.m.) (Control)	16	23.03	93.98	18.79	1.10	0.22	2.95	0.60	0.86	0.18	1.11	0.22
	0.93 (4 p.m.)	20	16.69	96.25	19.27	0.92	0.18	1.15	0.24	0.53	0.11	1.15	0.24
Z142	0.86 (1 p.m.) (Control)	16	25.12	92.86	18.58	1.74	0.34	3.14	0.68	0.95	0.19	1.31	0.26
	1.00 (4 p.m.)	20	17.27	95.38	19.09	1.57	0.32	1.20	0.25	0.82	0.16	1.03	0.21
Quality of the harvested rye grains from bunkers of the examined combines													
Z135B	0.76 (1 p.m.) (Control)	16	30.22	95.86	19.17	0.75	0.16	1.79	0.36	0.63	0.13	0.97	0.19
	0.98 (4 p.m.)	20	25.91	97.24	19.45	0.71	0.14	0.86	0.17	0.37	0.07	0.82	0.16
Z142	0.90 (1 p.m.) (control)	16	32.97	94.75	18.95	1.19	0.25	2.36	0.47	0.74	0.15	0.96	0.19
	1.15 (4 p.m.)	20	28.26	96.13	19.23	1.10	0.22	1.30	0.27	0.58	0.12	0.89	0.18

The lowest content of whole buckwheat grains in the harvested mass was measured in the bunker of the second examined control combine Z142: 92.86% (18.58 kgs). The combine had the speed of 0.86 m s^{-1}, a space underdrum-drum at the entrance was 16 mm, and periphery drum rotation was 25.12 m s^{-1}. The highest content of whole grains was found in the harvested mass of the combine 135B: 96.25% whole grains in the sample. While the space between the drum and underdrum at the entrance was 20 mm, the periphery drum speed was 16.69 m s^{-1}, and the moving speed of the combine was 0.93 m s^{-1}. Additionally the quantity of damaged grains deviated from 0.92-1.10%, which had been the content of the harvested mass of the combine ZMAJ135B, and 1.57%-1.74% (control, and adjusted variant) in the harvested mass of the combine ZMAJ 142.

The working devices of the combine driver Z135B, in a variant of our adjustments, did brake and peal significantly, though to a lesser extent than the control. The lowest content of broken and pealed buckwheat grains was 1.15% at 3 p.m. (0.24 kgs, compared to a sample of 20 kgs sampled from the combine bunker), with a rotation drum speed of 16.69 m s^{-1} and 20 mm of space between underdrum and drum at the entrance.

For the harvesting device of the combine Z142 to work, it cannot be said that it had been working on a higher quality level, considering that the harvested buckwheat mass has measured a very high content of broken and pealed buckwheat grains, 3.14% in the control.

The highest content of partially damaged buckwheat grains was measured in the harvested mass in the bunker of the second examined combine, registering 0.95% in control, while the lowest one was measured at 0.53% in the first combine (Z135B), which was a variant of ours with corrected parameters. The content of mechanical impurities was between 0.21- 0.26% control (combine Z142).

Comparing the results achieved in our trials, it can be noticed that they are similar to the results achieved in the papers of other authors (Auld et al., 1986.; Mayers etal.1994., 2007.; Beuerlien, 2001.; Mansoori and Minaee, 2003.; Vojvodic, 2002.; Malinovic et al., 2005.).

The same quality of work on the harvesting devices has been done for the rye harvest too. Based on the achieved results (Table 3), it can be noticed that harvesting with the combine Z135B worked better than the combine Z142. The highest average content of whole grains, 97.24% (4 p.m.) was noted in the harvested mass of the first combine (a working speed of 0.90m s^{-1}, and a periphery drum speed of 25.91 m s^{-1}). 25.91 kgs were used, compared to the sample of 20 kgs, with a space between the drum and underdrum of 20 mm, and only 0.75% o the grains were damaged. On the reverse, the lowest whole grain content was measured in the harvested mass of the combine ZMAJ 142: 94.75% (1 p.m.), with a working speed of 0.90m s^{-1}, and a periphery drum speed of 32.97 m s^{-1} (control). Approximately 1.19% of the grains were damaged. The harvesting device that was subject to our corrections experienced significantly lower rye grain breakage compared to the harvesting device with the adjustments made by the combine’s owners. Thus the lowest content of the broken rye grains was achieved at the harvested mass of the first combine, and it was 0.86% at 4 p.m. (periphery drum speed 25.91 m s^{-1}, space between underdrum and drum 20 mm), and the highest was in the control at 1 p.m.: 2.36%, with periphery drum speed of 32.97 m $s^{-1}$and an underdrum-drum space of 16 mm (combine Z142).

The highest content of partially damaged grains was measured in the harvested rye mass from the bunker of the combine ZMAJ 142 at 1 p.m. and it was 0.74% (control), with a periphery drum speed of 32.97 m $s^{-1}$and an underdrum-drum space of 16 mm. The lowest was 0.37% at 4 p.m. in the combine Z135B, a variant of the corrected parameters, with a periphery speed of 25.91 m s^{-1} and space between the drum and the underdrum of 20 mm.

Considering the presence of mechanical impurities in the harvested rye mass from the bunker, it should be noticed that it ranged from 0.82-0.97% (combine Z135B).

Similar research results have been presented by other authors who came across these issues: (Čuljat,1997.; Vojvodic, 2002.; Djevicet al., 2004.; Malinovic et al., 2005.; Barac et al., 2006.; Lashgari et al. 2008.).

CONCLUSION

The research into the effects of the threshing device was carried out in the agro-ecological conditions of the northern part of Kosovo and Metohia at two locations (the area of Leposavic, at $43^0$27’14’’N; $20^0$13’49’’E and Lesak, at $43^0$12’46’’N; $20^0$42’93’’E), with a humidity at 16.2% and 19.8%, respectively.

The harvesting TTO device and the combines ZMAJ 135B and ZMAJ 142 have been tested in harvests of buckwheat and winter rye. It can be concluded that changes in the defined parameters of tested combines can work, and significantly influenced the quality of the threshed mass. Corrections of relevant parameters, which we made in contrast to the control, have significantly influenced how tested combines work. The highest content of whole, undamaged buckwheat grains (96.25%) was measured as the harvested mass in the corrected variant combine 135B. The lowest whole grain content was in the combine Z142, with 92.86% in a control variant. Compared to the variant with changed parameter corrections, the control variant for both combines achieved the highest content of broken and pealed buckwheat grains. The lowest content of broken and pealed buckwheat grains was 1.15% (in the first tested combine), while a very high content of broken and pealed buckwheat grains was measured in the harvested mass of the second tested combine, and it was 3.14% (Control). The highest content of partially damaged buckwheat grains was measured in the harvested mass from the bunker of the second tested combine, and it was 0.95% in control, and the lowest was in the first combine, Z135B, and it was 0.53% in the corrected variant.

In the variant with corrections, all the combines simply had better ideas than the control. The highest average content (97.24%) of whole rye grains was found in the mass of the first combine, and the lowest (94.75%) was in the harvested mass of the control combine Z142. The lowest content of broken rye grains (0.86%) was measured in the harvested mass of the first combine, the corrected variant, and the highest (2.36%) was in control.

The highest content of partially damaged rye grains (0.74%) was measured in the harvested mass of the second control combine, and the lowest (0.37%) was in the second tested combine in the corrected variant.

In general it can be stated that the changes made to the defined parameters, compared to the control, and according to crop conditions at the experimental field, suggest that the work quality of the corrected variant may surpass the efficiency of the original combine. In general, the corrected variant may yet achieve in better results, though this may possibly be explained by its relative youth, compared to the other harvesting device, which had apparently been operating for decades.

ACKNOWLEDGEMENTS

The investigation published in this paper is a part of the "Improvement of biotechnological processes in the function of the rational use of energy, increase productivity and quality of agricultural products" project, financed by the Ministry of Education and Science of the Republic of Serbia. Grant No TR-31051.

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EFEKTI RADA VRŠEĆEG UREĐAJA KOMBAJNA I UTICAJ NA LOM I OŠTEĆENJA ZRNA HELJDE I RAŽI U ZAVISNOSTI OD DEFINISANIH PARAMETARA

SAŽETAK

Važan pokazatelj kvaliteta rada kombajna u toku žetve predstavlja pored visine ostvarenih gubitaka i kvalitet ovršene mase zrna. Kako u semenskoj robi, tako i u zrnu za preradu sadržaj polomljenog, oštećenog zrnai primesa je nepoželjan. U semenskoj robi, kao i robi za preradu, polomljeno i oštećeno zrno otežavaju čišćenje i čuvanje, a umanjuju i kvalitet dobijenog proizvoda. Vršeći uređaj kombajna ima značajnog uticaja na kvalitet ovršenogzrna heljde i raži. Na kvalitet rada utiče veći broj faktora: vlaga useva, usklađenost razmaka bubanj-podbubanj sa brojem obrtaja bubnja, tip vršećeg uređaja. U ovršenoj masi poželjan je visok sadržaj celog neoštećenog zrna od preko 95%, sa što manjim sadržajem polomljenog i oštećenog zrna.

Ključne riječi: heljda, raž, vršeći uređaj, kvalitet,zrno.